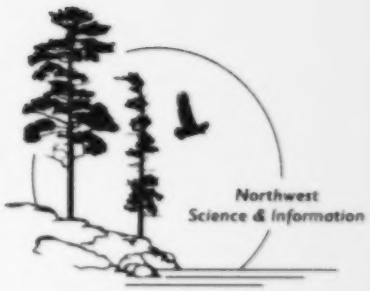

Forest Regeneration Standards in Ontario: A Historical Perspective

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by

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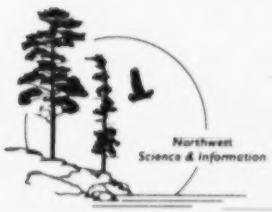

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Abstract

A historical perspective on the evolution of regeneration standards in Ontario is presented. A brief overview of how regeneration survey techniques evolved in Canada and Ontario precedes a discussion of renewal standards. Early renewal standards in Ontario are shown to have been introduced to add meaning to the interpretation of results from regeneration surveys. An explanation of how provincial standards developed and were then impacted by both the Forest Production Policy and the first Forest Management Agreements follows. The transition of the regeneration standard into a component of the Silvicultural Ground Rules in a forest management plan is described. Finaily, opportunities for inproving the link between standards and forest management objectives are discussed.

Key words: renewal standard, regeneration standard, stocking standard, regeneration, history, silviculture, Ontario

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Introduction

Regeneration standards[1] are used throughout Canada as a tool to assess the sustainability of forest management and to help determine if desired objectives are being met. They specify various criteria that are compared to conditions in regenerating stands to assess whether the results of reforestation activity were successful. Many jurisdictions across Canada are currently re-evaluating methods for setting standards to incorporate new knowledge regarding early stand dynamics and new tools for forecasting forest development (e.g. Newton 1998, Martin *et al.* 2002, OMNR 2004b, Buda 2005, White *et al.* 2005).

In this paper, the history and chronological development of regeneration standards in Ontario is examined to provide context for on-going discussions regarding their improvement. Their development is traced beginning with their use to interpret the results of early regeneration surveys. Periodic reconsideration of the standards to address concerns regarding sustained yield and to support the development of the provincial Forest Production Policy and Forest Management Agreements is documented[2]. The subsequent transition of regeneration standards into a component of the Silvicultural Ground Rules (SGRs) to meet specific objectives in Forest Management Plans (FMPs) is described. Finally, weaknesses in Ontario's current standards are discussed along with some possible improvements.

Evolution of Regeneration Surveys

Regeneration standards in Canada (and Ontario) have evolved in conjunction with the development of regeneration survey techniques. Armson (2005) provides an excellent overview of how regeneration surveys developed in Canada that is relevant background information to this discussion on renewal standards.

Armson (2005) notes the earliest surveys (pre-World War I) were not so much regeneration surveys as they are now known, but rather surveys limited in scale and intensity to provide a broad overview of the nature of forests. It was not until the end of World War I that any significant attempt to conduct regeneration surveys occurred. These surveys were driven by academic, professional and, to some degree, political interests to address questions regarding the rate of forest depletion and renewal. Early federal surveys often focused on logged-over or burned-over lands and were conducted using large plots assessed along a strip every two or five chains[3]. Results were expressed in numbers of trees per unit area, not in stocking. Sampling intensity was still often quite low and results were often extrapolated over large areas (Armson 2005).

Between 1919 and 1951, there were many surveys conducted in Ontario by both the Department of Lands and Forests and a number of pulp and paper companies who were interested in the status of regeneration on their limits; these are summarized and reviewed by Hosie (1953). These surveys were conducted using various survey methodologies and, most notably, plot sizes. The Ontario Department of Lands and Forests conducted surveys using large assessment plots

[1] The terms regeneration standards and renewal standards are used interchangeably in this document.

[2] Regeneration standards that were published for province-wide application in Ontario are reproduced in the appendices in chronological order.

[3] 1 chain = 66 feet = 20.1 metres

(1/20 acre). It was not until near the end of World War II that the use of smaller assessment plots – usually 1/1000 acre (milacre) – became common (Armson 2005):

> *"The use of the quadrat as a sampling procedure was introduced by late 19th century ecologists, and was not picked up by foresters until the 1920's. At that time the U.S. Forest Service used 1/16 acre plots (as compared with 1/20 acre plots used in Ontario) which were time-consuming and expensive to measure with results expressed in densities (nos. per acre). In 1927, Lowdermilk (U.S. Forest Service) proposed using the quadrat system of the ecologists to measure what they termed frequency index of occurrence and what he proposed as stocking expressed as a percent."*

The eventual adoption of milacre plots as a survey standard has been linked to the initiation of planting programs for the reclamation of waste lands, such as occurred in southern Ontario (Armson 2005):

> *"... general planting on bare lands, as in southern Ontario, where a common spacing of 6 ft. by 6 ft. allowing for some irregularity, resulted in approximately 1000 trees per acre, more or less uniformly distributed. Thus, it was reasoned that between 80% and 100% stocking using a milacre quadrat in cutovers would represent the type of stocking attained by planting. With the increasing use of smaller plot sizes an emphasis was placed on stocking as opposed to density."*

At this time it was also recognized that, due to their cost, ground survey techniques should be directed to assess specific forest conditions (Armson, 2005):

> *" ... for foresters experienced in the local forest it is not difficult to identify the areas which are obviously satisfactorily or not satisfactorily regenerated. It is in the middle areas whereby observation may be questionable that surveys are required."*

The Notion of Standards

Compilers and readers of early surveys in Ontario often questioned their meaning and interpretation. The results were often ambiguous due to the use of various methodologies and, particularly, different plot sizes (Hosie 1953). Stocking standards had been used by some investigators in an attempt to aid in the interpretation of survey results (Hosie 1953). These stocking standards were often stated as pre-specified ranges of stocking percent that suggested the adequacy of regeneration on a given site. Hosie (1953) identified a need to cautiously interpret these numbers. For example, in his comprehensive review of surveys conducted throughout Ontario from 1918 through 1951, Hosie (1953) noted the standards in use by the provincial Forestry Branch in 1953 were as follows (using a plot size of 1/1000 acre):

- 80 to 100% - fully stocked
- 60 to 79% - well stocked
- 40 to 59% - moderately stocked
- 20 to 39% - under stocked
- under 20% - failure

Because plot size affects stocking figures (Hosie 1953, Bella 1976, Armson 2005), Hosie (1953) cautioned that these standards were not necessarily applicable to all of the surveys that had been conducted at the time; such blanket application would have resulted in misinterpretation of results. Hosie (1953) cited the example of one industry survey, which utilized 1/600 acre plots, reporting a 20 percent stocking figure which would have been equivalent to 13 percent stocking based on the 1/1000 acre plot used by the Forestry Branch.

Despite some shortcomings, Hosie (1953) noted the usefulness of using standards to focus forest management activities:

> *"...the use of [such] standards has the effect of suggesting future possibilities. Areas [arbitrarily] classed as failures [e.g. based on stocking] are looked upon as being inadequately stocked to produce a merchantable crop. This suggestion raises the question, What is adequate stocking?"*

Hosie (1953) identified a number of issues at the time which made that a very difficult question to answer: *"... no one knows for any given species at any given age during the early development of the stand what stocking is necessary to ensure a future crop..."*. Further complicating matters was the recognition that it was *"... not known that any particular quadrat size [would] correctly express the real significance of stocking percentages nor [did] it seem likely that one [could] readily be determined"* (Hosie 1953). Still, Hosie (1953) recognized *"... tentative standards will still have to be set and doubt will remain regarding their reliability"*. These were the considerations as early renewal standards were developing in the province.[4]

Standards of Stocking: Discussions in Ontario—1959

In 1959, the issue of renewal standards in Ontario was being raised in response to a stated provincial policy of sustained timber yield (Hueston *et al.* 1959). At the time, regeneration success was almost synonymous with sustained yield, defined as *"regeneration that will result in stands at least as good as those being cut* (Hueston *et al.* 1959)". While the view was held by many industry and government foresters that regeneration success was best determined by the opinion of the *"professional foresters on the ground"* (e.g. Hosie 1953, Hueston *et al.* 1959), the Ontario government recognized that a more objective approach was required to address some of the regeneration problems that were occurring at the time (Hueston *et al.* 1959).

For many years, at various intervals, discussions had been taking place regarding the establishment of standards of stocking for managing the forests of Ontario (Lyon 1959). In 1959, the Advisory Committee to the Minister of Lands and Forests agreed to set up a subcommittee to study regeneration problems for the province, including the issue of stocking standards. The committee consisted of industry and government foresters and a technical advisor from the Faculty

[4] It should be noted that stocking standards had been in use in various forms in other jurisdictions prior to the work by Hosie (1953). Armson (2005) provides a good overview of some of these earlier standards; briefly, the U.S. Forest Service had been using milacre quadrat plots for some time, and had been using a stocking figure of 40 percent to define regeneration in excellent condition. Forty percent stocking based on milacre plots was also used in Canada in the 1950s by Smith and Kerr (1958) to represent a minimum for adequate regeneration on the University of British Columbia forest at Haney, B.C. (Armson 2005).

of Forestry of the University of Toronto (McMahan 1959). The subcommittee met on six occasions but was finally disbanded when it was determined that the subcommittee members could not reach *"substantial agreement on the subject of stocking standards"* (Anon. 1959). As the subcommittee was disbanded, a recommendation was made that *"since the problem of establishing stocking standards is essentially the problem of the land owner ... a Departmental Committee [should] be established to study the problem ..."* (Anon. 1959).

Committee on Standards of Regeneration Stocking—1959

In response to this recommendation, the Committee on Standards of Regeneration Stocking (CSRS) was formed in 1959 and consisted of research and district foresters from the Department of Lands and Forests. The committee was charged with two objectives (Hueston *et al.* 1959):

- To examine techniques and results of the various regeneration survey methods in place across Ontario with the hope of understanding the current state of regenerating lands in the province.
- To establish stocking standards for regenerating stands that would, at minimum, provide for fully-stocked stands of various commercial species at maturity.

Meetings and field trips were held across Ontario to consult with experts in industry, academia, and government and to view stand conditions. Input from discussions held at these meetings was considered in the development of the stocking standards presented in the final report by the CSRS (Hueston *et al.* 1959) (see Appendix A).

In their report, the CSRS recognized the difficulty in attempting to apply to the province a blanket (average) standard that would fit every situation. In particular, the need for site-specific standards that would vary with management intensity was identified. It was suggested that a blanket standard would be too low for highly productive, accessible sites close to mills (i.e. sites suited to more intensive management), and too high for less productive, remote sites (i.e. sites better suited to extensive management).

In addition to recognizing the need for a more site-specific approach to stocking standards, the CSRS also identified the need for species-specific standards. Accordingly, standards were presented for each of the working groups[5] prevailing in Ontario at that time. The committee found *"no valid reason why the species now sustaining [Ontario] in its high position should be changed"* (Hueston *et al.* 1959).

The standards themselves consisted of a minimum density, a minimum stocking, and a time limit on the establishment period. The required minimum densities varied by working group. Stocking was based on the number of milacre plots on which at least one established stem[6] of the working group species occurred. All working groups were required to meet a 60 percent stocking standard within five years of harvest.

[5] In Hueston *et al.* (1959), a working group was defined as an aggregate of stands having the same predominant species and rotation.

[6] An established stem is defined as a stem on which there is no apparent factor acting to prevent it reaching merchantability (Hueston *et al.* 1959).

The primary objective of these standards was, at minimum, to provide for fully-stocked stands of the various commercial species at maturity. Further, the CSRS stated *"we should be trying to grow good form stems of the species best suited to the site which will produce the highest value end product"* (Hueston *et al.* 1959). The (somewhat subjective) standards presented in the CSRS report were based on expert opinion, and had no direct quantitative linkage to their objective since standardized provincial information that related regenerating stand characteristics to stand development was not available at the time.

The committee submitted their report to the Timber Branch of the Department of Lands and Forests in late 1959. It was a year later before the final report of the committee was circulated to the various field offices. When the report was circulated, a covering letter from the Timber Branch indicated that the recommendations of the committee *"should be regarded essentially as a guide for the person faced with the decision of prescribing certain action in the interests of regeneration. These standards should not be used without taking into account the conditions which exist on the area being studied. The forester or other trained person has the final responsibility for making the decision ..."* (Brodie 1960). As a result, the use of these standards was at the sole discretion of local field staff.

In addition, the covering letter indicated that the standards were not intended for any areas other than where "the total responsibility for regeneration rest[ed] with [the] Department [of Lands and Forests]" (Brodie 1960). It was mandated that the standards should be restricted to those areas solely under management of the government and tested there first before their application was recommended to other areas. This meant that the standards were only applicable to the Crown Management Units, which tended to be small and harvested by small permit holders. There was some concern expressed regarding the limited scope of application of these standards (Burgar 1961, McLean 1961). It was felt that conditions on the Crown units were not representative of renewal problems that were occurring on the large limit holdings of the pulp companies (Lyons 1961), where the companies had complete responsibility for harvesting and regeneration (until 1962) and were rapidly mechanizing their logging operations (Armson 2001).

The benefit of putting general standards in place quickly was, however, considered more important than taking the additional time required to develop more refined, site-specific standards (Hueston *et al.* 1959). As stated in the report by the committee, *"The need for standards is far greater than the need for refined standards. We should begin to intensify our management at once, using the best knowledge available, and improve as we go along"* (Hueston *et al.* 1959). The committee hoped these preliminary general standards would stimulate a program of testing and evaluation that would lead to improvements to the standards over time (Lyon 1961). The debate over the standards and proposals to revise stocking standards did continue (e.g. Canadian Institute of Forestry 1971), although a coordinated effort to test the standards does not appear to have occurred.

Forest Production Policy Impacts: Standards for Timber Production—1971

In the early 1970s, the Ontario Ministry of Natural Resources (OMNR) took a strategic look at the degrees of silvicultural investment required to support various levels of timber harvest in the province. The costs and staffing requirements associated with the various options were investigated and one was selected as the Forest Production Policy for Ontario (OMNR 1974).

In 1971, coincident with these activities to evaluate timber production options, the province issued the Minimum Stocking Standards for Timber Production for the Province of Ontario (OMNR 1971)(see Appendix B). The desirable stocking levels in these standards were set with the expectation that they would lead to the production of *"a stand at maturity with a factor of 0.8 of normal stocking, according to the [Plonski 1960] Normal Yield Tables"* (OMNR 1971). The stocking standards were to be assessed at the end of the regeneration period, which varied by working group and treatment type. Both stocking levels and densities were incorporated into the standards to indicate desirable, failure, or unsatisfactory conditions. For each working group, detailed specifications were provided to indicate appropriate levels (too few or too many) for both primary and secondary acceptable species. For example, for the black spruce working group, desirable stocking was set at greater than 60 percent stocking to the working group species and a density of less than 5000 trees per acre. Conditions (stocking levels and densities, by species) were also described under which release should be considered. Conditions that fell between desirable and failure were classed as unsatisfactory and were considered to be areas eligible for treatment to bring them up to desirable standards. If left untreated, stands in this category *"must be considered as yielding somewhat less that 0.8 stocking at maturity"* (OMNR 1971).

Although some of the specifications in the standards were open for interpretation, they were viewed to be a progressive step forward (Lyon 1971). The standards were to be applied across the province on all sites, which provided a good opportunity for testing and evaluation. In addition, the desired working group for a stand was now to be declared at the time of harvest, rather than after renewal treatment, which provided an opportunity to assess silvicultural effectiveness (Dixon 1972).

Revisions to Assessment Procedures

In conjunction with the 1971 standards, the province issued a set of regeneration assessment instructions *"in order to ascertain if an area has reached desirable stocking as defined by the Forest Management Branch, minimum stocking standards, Nov. 1971."* (OMNR 1973). A stocking assessment was to be conducted at the end of the regeneration period (five to seven years) on all areas that should be regenerating in order to meet production targets. This included planted and seeded areas as well as areas regenerated by modified cutting, seed trees, and natural regeneration. The assessment procedure was a stocked plot assessment to be conducted by systematic sampling using milacre quadrats with a random start. The plot was considered stocked *"if one or more healthy seedlings that will probably survive to maturity occurred in the plot."* (OMNR 1973). Information was also recorded to determine the need for further treatment, such as release or insect spraying.

In the late 1970s, the OMNR produced various drafts of the 1973 regeneration survey instructions, culminating in the publication of the *Regeneration Survey Manual* for Ontario (OMNR 1981). The manual was designed *"to provide uniformity in the methods and standards of assessment and evaluation of regeneration success and provide meaningful information on the state of regeneration to various levels of management"* (OMNR 1981).

The manual described procedures for conducting stocking and Free-to-Grow (FTG) assessments, as well as plantation survival and seeding assessments. All of these were conducted by the OMNR on a percentage of the areas that they

managed with the objective of providing meaningful information on the state of forest regeneration (OMNR 2001). Survival and seeding assessments were used to provide early detection of failures and to analyze treatment success in relation to a number of variables. Stocking assessments were to be completed five years after treatment *"to determine the relative success of regeneration on an area according to prescribed stocking standards and to provide forest managers with basic information on stand establishment in order to predict future yields"* (OMNR 1981). Stocking assessments were also to be used to determine the need for future treatment, such as release. A stocked plot was determined by considering both minimum heights and number of trees. If trees did not meet the minimum height for the species, plots could still be considered stocked to conifers if there were *"three or more healthy trees 2 years or older of any height"* (OMNR 1981). Free-to-Grow assessments were conducted separately from stocking assessments and were used to determine the FTG status of conifers only. The timing of this assessment depended on the working group and the treatment type (i.e. planted (bareroot or container) or seeded).

Revised Regeneration Standards Prior to Forest Management Agreements—1977

In 1977, the Minister of Natural Resources initiated negotiations with the forest industry to outline a mechanism whereby the industry could assume forest management responsibilities to better integrate harvesting and silvicultural activities (Armson *et al.* 2001). These discussions eventually led to the signing of the first Forest Management Agreements (FMAs) in the early 1980s, which outlined the contractual arrangements between the government and industry to conduct forest management on the FMA areas.

As these discussions were being initiated, the government issued a revised set of stocking standards (OMNR 1977) (see Appendix C)[7]. These standards reflected similar objectives as the 1971 standards, with good stocking levels being set with the expectation that the stand will develop *"to produce a stand at maturity with a factor of at least 0.8 of normal stocking"* (OMNR 1977). Various stocking percentages of primary and secondary conifers and hardwoods were assigned to each working group to indicate good and failure stocking levels. There were a number of changes from the 1971 standards, however, which occurred as a result of *"comments and proposals ... received from field staff"* (Fullerton 1977). The quadrat size for assessing the standards was increased from four to five square metres, a significant development (OMNR 1977). The standards removed all references to density (because of the cost associated with collecting this information) and deleted any specifications which indicated conditions where tending or release should be considered. Good stocking for spruce and jack pine working groups was defined as greater than or equal to 60 percent stocking to the working group species (based on a five square metre assessment plot) and greater than 70 percent to all primary and secondary species. These were the provincial standards in place when the details of the SGRs for each individual FMA were being negotiated.

[7] These standards were produced by Fred Robinson, Boreal Silviculturist for the OMNR at the time. *"These were based on his review of standards being used in the field by government and company foresters."* (Armson 2005).

Forest Management Agreements—1980s

As the new FMAs were being introduced, the various obligations under the new agreements were described in the *Forest Management Manual for the Province of Ontario* (Armson *et al.* 1980). Ground rules were required to be developed for each FMA to outline the guidelines for silvicultural activities. Stocking standards were part of the ground rules and were to be developed jointly by local Ministry and company staff. These negotiated standards replaced the 1977 provincial standards and were intended to more clearly link with specific objectives for the agreement area (Armson 2005). The stocking standards were required to indicate desired and satisfactory levels of stocking that were to be assessed in the fifth year following regeneration. A minimum standard was set as the failure level and companies were obligated to re-treat failures at their own expense. Because of this obligation, government foresters were encouraged to initially allow these negotiated standards to be more lenient than the 1971 provincial standards until the companies gained expertise in silvicultural operations (Robinson, pers. comm., 1980). These standards were to be assessed by the companies using a four square metre quadrat size[8]. The assessment system used by the OMNR was suggested as the preferred method of assessment, and it was designated as the procedure to be used for auditing purposes.

The development of the FMAs and the *Forest Management Planning Manual for Ontario's Crown Forests* led to the further development of the FTG concept and terminology in Ontario. Free-to-Grow surveys were the responsibility of the Crown and were to be conducted in a reasonable time period after a request was made by a company to survey an area that they had declared satisfactorily regenerated. Only areas which had been assessed as FTG by the Minister were to be added back to the production forest land base for the determination of the annual allowable harvest cut (Armson *et al.* 1980). The FTG survey was to be conducted using 50 square metre plots in clusters of three, usually with six clusters per stand. A stand was considered FTG when *"it is above the minimum stocking standard[9] and the total height of its working group species is at least one metre and is judged to be essentially free from competing vegetation of other species."* (Armson *et al.* 1980).

Provincial Review of Stocking Standards—1988

In the late 1980s, OMNR conducted a review of renewal standards across Ontario as a component of a larger examination of the Silvicultural Information System (SIS) being developed for the province (Pat Corbett, pers. comm., January 2005). This review involved a number of regional meetings involving industry and government foresters to evaluate the suitability of renewal standards and resulted in a series of stocking standards being proposed for each of the OMNR administrative regions. The review also gave rise to a series of policy directives (OMNR 1988a, b, c, d, e)[10] in which each administrative region was to maintain sets of benchmark FTG standards for each of the predominant forest sections (after Rowe 1972) and working groups/forest units in the respective regions. Under these directives, regional committees were to be established that would periodically

[8] This was a change back from the five square metre plot used since 1977. It was consistent with drafts of the new Regeneration Assessment Manual which was soon to be released (OMNR 1981).

[9] The minimum stocking standards referenced here were the standards negotiated in each of the individual SGRs.

review the renewal standards to ensure their continued relevance. Deviations from the benchmark standards were acceptable, subject to approval during the forest management planning process. Finally, consolidation of standards for similar biological forest sections among regions was encouraged (OMNR 1988b). In a separate directive, the roles and responsibilities of the regional foresters and regional FTG standards committees were outlined to ensure renewal standards were kept current and reviewed periodically (OMNR 1988b, c).

The development of these regional directives was a useful exercise because it helped focus on many of the key issues, and the lack of objectivity, surrounding the development of renewal standards. The standards being proposed at the time were based largely on expert opinion and the testing of renewal standards had not progressed much since originally proposed by the 1959 committee. The process outlined in the directives for reviewing and revising regional renewal standards was quickly superseded by the process of developing SGRs in individual forest management plans. In addition, the procedures outlined in the directives were further undermined by the administrative restructuring of OMNR in 1992 and the elimination of some of the key positions, such as Regional Forester, referenced in the directives.

Current Renewal Standards—A Component of Silvicultural Ground Rules

The process for developing renewal standards currently continues to be incorporated into the management planning process. Renewal standards are a component of the SGRs, which are developed by the forest management planning team, and are then subject to various levels of approval. This ostensibly provides an opportunity to link renewal standards to specific stand level objectives detailed in the SGR. The objectives in the SGRs themselves are intended to link to higher order forest level objectives expressed in the forest management plan.

Renewal standards are just one of four components of SGRs in Ontario. The other components are the current forest condition, the future (target) forest condition and the silvicultural treatment package (OMNR 2001).

The current stand condition includes a description of the composition of the stand (prior to disturbance), the forest unit to which it is presently assigned, and a detailed site description (e.g. ecosite). This information is essential for determining appropriate management objectives and possibilities for the site (i.e. "What do we have? What can we do? What do we want to do?").

The future forest condition is the management objective for the regenerating stand (i.e. the desired outcome of silvicultural activities (after OMNR 2001)). It indicates the forest unit that is expected to develop and may include a detailed description of the predicted stand characteristics at some future time (e.g. average stand diameter; species composition). Another component of the future forest condition is quantitative stand development information, such as a yield curve.[11]

[10] Interestingly, a fairly detailed directive (OMNR 1988d) was also produced at this time relating to silviculture effectiveness monitoring. It was defined, outlined, and deemed essential to Ontario. Additional directives provided the definitions for FTG stands, silvicultural effectiveness monitoring, regeneration effectiveness monitoring, ineffective silviculture, standards of performance and the timing of surveys that may be conducted throughout the life of a stand (i.e. condition surveys; survival, stocking and tending surveys; and FTG assessments) (OMNR 1988a, d, e).

[11] The exact nature of the stand development information varies depending on available data and decision support tools available for a given management unit.

The silvicultural treatment package includes the selection of the silvicultural system, the harvest method, and any renewal and tending treatments that will be used in vegetation management (OMNR 1996). Essentially, it is the planned method of achieving the desired future forest condition (management objective) specified in the SGR (OMNR 2001).

Future Development of Regeneration Standards

The regeneration standard may serve two roles. It may be viewed as a performance measure used to assess the immediate results of regeneration treatments (i.e. did the treatment result in sufficient numbers of seedlings being established?). This short term perspective of regeneration standards has commonly been the rationale behind the negotiation of the standards in the SGRs, tempered by the mindset that too high a standard may result in re-treatment obligations. However, if the regeneration standard is considered a predictive tool and is developed to be consistent with stand development attributes associated with the desired future forest condition (as it was intended) (OMNR 1996, 2004), the standard may be used to make an early determination of whether or not the stand is tracking towards (or has the potential to track towards) the desired management objectives. This "early warning" aspect of the standard would be a powerful tool which would allow for timely adjustment to silvicultural practices, modeling inputs, and wood supply forecasts.

The current forest management planning manual recognizes this long-term role for regeneration standards and specifies that *"the standards of regeneration success must be consistent with the development information associated with [the] silvicultural ground rule"* (OMNR 2004a), although there is no guidance or direction on how this is to be accomplished. The determination of renewal standards is left to the discretion and expertise of the individual forest management planning and review teams. Standards are still largely determined through negotiation, although individual initiative has resulted in the use of various information sources and planning tools to improve the development of the standards. Consequently, renewal standards often vary, without justification, across planning areas and with each subsequent plan renewal.

Recent improvements to forest modeling tools, such as density management diagrams and managed stand yield curves, provide an opportunity to improve the relationship between regeneration standards and longer term forest conditions (OMNR 2004b). These forecasting tools could be incorporated into a step-by-step procedure that considers components of the standard, such as species composition, density targets and performance measures, in a systematic manner. Such an approach would ideally help rationalize renewal standard development, resulting in standards with quantified thresholds of stand attributes with a stronger link to target mature forest conditions (White, Reid, and Buda 2007 (draft)). Developing standards in this manner would also increase understanding of forest development and provide opportunities for improved decision-making through adaptive management (ARSSC 2001). Approaches for developing standards will continue to evolve and new standards should be tested using long term monitoring programs. As stated by the 1959 Committee, we should continue to move forward to *"intensify our management ... using the best available knowledge, and improve as we go along."* (Hueston *et al.* 1959).

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Appendix A

Report of the Committee on Standards of Regeneration Stocking—December 1959

Committee

T.W. Hueston, Personnel Section, Toronto
N.F. Lyon, Research Forester, Port Arthur
G.A. McCormack, Timber Forester, Port Arthur
G.A. Ashenden, Timber Forester, Port Arthur

Meetings

1. Sault Ste. Marie – August 5, 1959
2. Port Arthur – Field Trip – October 19, 1959
   Port Arthur – October 20, 1959
3. Toronto – November 25, 26, 27, 1959

People Consulted

1. Industrial Foresters: many of those working in the districts represented by the committee members as well as others encountered on field trips and during informal meetings.
2. University: Professors Hosie and Love of the Faculty of Forestry
3. Department: Foresters in various districts as well as in the Research Branch and Silviculture Section.

Terms of Reference

1. To study specifications for regeneration surveys being undertaken in the Province by various agencies and the possibility of correlating their results in order to provide the basis for a realistic appraisal of the regeneration problem on the cut-over lands throughout the Province.
2. To establish standards of stocking that are believed necessary to provide for fully stocked stands of various commercial species at maturity.

Standards of Stocking for Regeneration

Foreward

The declared forest policy in Ontario is that of sustained yield. Sustained yield presupposes regeneration that will result in stands at least as good as those being cut. The adequacy of such regeneration can best be judged by professional foresters on the ground. Until we reach this stage there is need for some standard by which to judge regeneration.

The committee recognizes that no usable set of standards will fit every situation. It will be too low for highly productive, more accessible sites and too high for low production, distant sites.

To avoid complexity, the standards contain no reference to site as such. However, it is obvious that site productivity must be recognized when deciding how much effort should go into obtaining regeneration.

We discussed several of the attendant problems, such as who will be responsible for doing the necessary work, who will pay for it, what silvicultural methods should be used, and the old questions of tenure and accessibility. Because these were considered as not falling within our terms of reference, no solutions are herein suggested.

In evolving our standards the following points were considered:

1. We should be trying to grow good form stems of the species best suited to the site which will produce the highest value end product. Regarding species, we could think of no valid reason why the species now sustaining the province in its high position should be changed.
2. The need for standards is far greater than the need for refined standards. We should begin to intensify our management at once, using the best knowledge available, and improve as we go along.

Regeneration Survey Specifications

Our investigations into the matter of regeneration surveys disclosed that a considerable number of techniques are being used and that most have some merit.

To determine whether or not the regeneration on an area meets the required stocking standards, a survey must show if the desired species is present in sufficient numbers, if it is well distributed, and if it is established.

A regeneration survey with the following broad specifications would supply this information. Further refinement is left to the agency doing the survey.

Plot Size—The mil-acre quadrat is the recommended size. It is suggested that the mapping of plots helps to indicate which parts of an area require treatment.

Distribution—determined by the use of "stocking" quadrats on which the presence or absence of regeneration of all species is recorded. The result and degree of stocking or per cent occurrence indicates distribution.

Numbers per Acre—We recommend the use of "list" quadrats on which the actual numbers of regeneration of all species are counted and recorded.

Establishment (Condition)—we recommend the recording of detailed information on factors that determine if a stem is "established." Among these will be forest cover type, soil site type, time since disturbance, age of regeneration, total height, annual height growth, tolerance, kind and condition of competition, suppression, appearance, health and origin.

Definitions for Terms Used in These Standards

1. Established stem – a stem on which there is no apparent factor acting to prevent it reaching merchantability.
2. Working group – an aggregate of stands having the same predominant species and rotation.

Standards

1. Spruce – fir (with poplar – white birch) working groups

   Primary species – spruce

   Standards

   750 established spruce stems per acre at 60 percent stocking within five years of removal of original crop.

2. Jack pine – black spruce working groups

   Primary species – jack pine and/or spruce

   Standards

   1,000 established jack pine and/or spruce stems per acre at 60 percent stocking within five years of removal of original crop.

3. Black spruce working groups

   Primary species – black spruce

   Standards

   1,000 established spruce stems per acre at 60 percent stocking within five years of removal of original crop.

4. Jack Pine working groups

   Primary species – jack pine

   Standards

   1,000 established jack pine stems per acre at 60 percent stocking within five years of removal of original crop. Some amounts of spruce and red pine are acceptable regeneration in these working groups.

5. White pine working groups

   Primary species – white pine

   Standards

   750 established white pine stems per acre at 60 percent stocking within five years of removal of original crop. Some amounts of red pine and white spruce are acceptable regeneration in these working groups.

6. Tolerant hardwood working groups

   Primary species – yellow birch

   Standards

   1,000 established yellow birch stems per acre at 60 percent stocking within five years of removal of original crop.

Appendix B

Province of Ontario Minimum Stocking Standards for Timber Production—November 1971

Stocking (Distribution)

- based on a mil acre quadrat assessment.

Regeneration Period

- the number of years allowed for regeneration to become established. Periodic inspections should permit a decision on stocking to be made at the end of the regeneration period.

Desirable Stocking Determined by Mil Acre Quadrats

- this is the minimum stocking required at the end of the regeneration period, and it is expected to produce a stand at maturity with a factor of 0.8 of normal stocking, according to the Normal Yield Tables. (Plonski 1960).

Failure

- regeneration assessed as failure cannot be considered to be capable of producing any part of the output target for the unit. Further treatment, if the benefit cost ratio allows, may permit reassessment.

Unsatisfactory

- regeneration assessed as between desirable and failure is classed as unsatisfactory. Work may be done to bring it to desirable standards. If left alone, it must be considered as yielding somewhat less than 0.8 stocking at maturity.

Release

- if release is not done when required, area must be reassessed periodically to determine condition. It may become unsatisfactory or a failure, or the rotation may have to be lengthened.

Dominant Species

- species which are overtopping other more desirable species.

On certain site conditions variations in the working group will be encountered where poplar, spruce, balsam or other species can receive greater consideration that those specified in the minimum stocking standards for the group.

Black Spruce Working Group

1. Regeneration period –

   7 years (5 years if planted)

2. Acceptable species –

   primary – black spruce

   secondary – white spruce, jack pine

3. Desirable stocking –

   Each of the following conditions should be met:

   a) black spruce – more than 60 percent

   b) spruce plus jack pine – more than 70 percent

   c) balsam plus poplar – less than 20 percent

4. Desirable trees per acre –

Less than 5,000 spruce and jack pine

5. Failure –

If either of the following conditions apply:

a) black spruce – less than 40 percent stocking

b) spruce plus jack pine – less than 50 percent stocking

6. Release –

May be required if either of the following conditions apply:

a) spruce plus jack pine – more that 10,000 trees per acre

b) dominant poplar – more than 30 percent stocking

Jack Pine Working Group

1. Regeneration period –

5 years

2. Acceptable species –

primary – jack pine

secondary – spruce

3. Desirable stocking –

Each of the following conditions should be met:

a) jack pine – more than 60 percent

b) jack pine plus spruce – more than 70 percent

c) dominant poplar – less than 10 percent

4. Desirable trees per acre –

Less than 5,000 jack pine and spruce

5. Failure –

If either of the following conditions apply:

a) jack pine – less than 40 percent stocking

b) jack pine plus spruce – less than 50 percent stocking

6. Release may be required –

If any of the following conditions apply:

a) jack pine plus black spruce – more than 10,000 trees per acre

b) dominant poplar – more than 30 percent stocking

White Spruce Working Group

1. Regeneration period –

5 years (7 years if natural)

2. Acceptable species –

primary – white spruce

secondary – black spruce, red spruce, balsam, jack pine, poplar, white birch, white pine, hemlock, tolerant hardwoods

3. Desirable stocking –

Each of the following conditions should be met:

a) white spruce – more than 50 percent

b) primary and secondary species – more than 70 percent

c) balsam – less than 20 percent
d) dominant poplar – less than 30 percent

4. Desirable trees per acre –
balsam – less than 1,000 trees per acre

5. Failure –
If any of the following conditions apply:
a) white spruce – less than 30 percent stocking
b) spruce – less than 40 percent stocking

6. Release may be required –
If any of the following conditions apply:
a) dominant hardwoods – more than 40 percent stocking
b) balsam – more than 30 percent stocking

Balsam Fir Working Group

1. Regeneration period –
5 years (usually present as advance growth)

2. Acceptable species –
primary – balsam
secondary – spruce and poplar

3. Desirable stocking –
Each of the following conditions should be met:
a) balsam – more than 60 percent
b) balsam plus spruce – more than 70 percent
c) dominant poplar – less than 20 percent

4. Desirable trees per acre –
balsam – less than 5,000 trees per acre

5. Failure –
If any of the following conditions apply –
a) balsam – less than 50 percent stocking
b) balsam plus spruce – less than 60 percent stocking

6. Release may be required –
If any of the following conditions apply –
a) balsam – more than 10,000 trees per acre
b) dominant poplar – more than 30 percent stocking

Poplar Working Group

1. Regeneration period –
5 years

2. Acceptable species –
primary – poplar of good quality
secondary – spruce, white pine, balsam, white birch, jack pine

3. Desirable stocking –
The following condition should be met:
poplar – more than 80 percent

4. Desirable trees per acre –
   poplar – more than 5,000 trees per acre
5. Failure –
   If any of the following conditions apply –
   a) poplar – less than 3,000 trees per acre
   b) poplar – less than 50 percent stocking
   c) poplar – of poor quality
6. Release may be required –
   If the following condition applies:
   poplar – more than 10,000 trees per acre

White Birch Working Group

1. Regeneration period –
   5 years
2. Acceptable species –
   primary – white birch
   secondary – spruce, white pine, balsam, poplar, jack pine
3. Desirable stocking –
   white birch – more than 80 percent
4. Desirable trees per acre –
   white birch – more than 5,000 trees per acre
5. Failure –
   If any of the following conditions apply:
   a) white birch – less than 3,000 trees per acre
   b) white birch – less than 50 percent stocking
6. Release may be required –
   If the following condition applies:
   white birch – more than 10,000 trees per acre

Other Conifer Working Group

1. Regeneration period –
   7–10 years, 5 years when planted
2. Acceptable species –
   primary – cedar, larch
   secondary – spruce, balsam, pine
3. Desirable stocking –
   Each of the following conditions should be met:
   a) cedar, larch – more than 40 percent
   b) all acceptable species – more than 60 percent
4. Desirable trees per acre –
   less than 5,000

5. Failure –

If any of the following conditions apply:

a) cedar, larch – less than 30 percent stocking

b) all acceptable species – less than 40 percent stocking

6. Release is not normally practised.

Red Pine Working Group

1. Regeneration period –

5 years

2. Acceptable species –

primary – red pine

secondary – white pine, spruce, jack pine

3. Desirable stocking –

Each of the following conditions should be met:

a) red pine – more than 50 percent

b) all acceptable species – more than 70 percent

c) balsam plus poplar – less than 10 percent

4. Desirable trees per acre –

less than 5,000

5. Failure –

If either of the following conditions apply:

a) red pine – less than 40 percent stocking

b) pine and spruce – less than 50 percent stocking

6. Release may be required –

If the following condition applies:

dominant poplar – more than 20 percent stocking

White Pine Working Group

1. Regeneration period –

5–7 years

2. Acceptable species –

primary – white pine

secondary – red pine, spruce, poplar, balsam, jack pine, tolerant hardwood, hemlock

3. Desirable stocking –

Each of the following conditions should be met:

a) white pine – more than 50 percent

b) all acceptable species – more than 70 percent

c) balsam – less than 10 percent

d) dominant poplar – less than 20 percent

4. Desirable trees per acre –

less than 5,000

5. Failure -

If any of the following conditions apply:

a) white pine – less than 40 percent stocking

b) pine and spruce – less than 50 percent stocking

6. Release may be required –

If any of the following conditions apply:

a) dominant poplar – more than 40 percent stocking

b) balsam – more than 30 percent stocking

Hard Maple, Yellow Birch, Hemlock Working Groups

1. Regeneration period –

5–10 years

2. Acceptable species –

Northeastern Region – yellow birch, hard maple, white pine, oak, ash, white birch, hemlock, spruce

Southern Region – hard maple, soft maple, white pine, yellow birch, basswood, beech, poplar, spruce, ash, oak, white birch, cherry, plus some Carolinian species in southwestern Ontario

3. Desirable stocking –

Acceptable species more than 80 percent

4. Desirable trees per acre –

Acceptable species more than 5,000

5. Failure –

If the following condition applies:

Acceptable species less than 50 percent

6. Cleaning may be required –

If dominant unacceptable species exceed 30 percent

Appendix C

Province of Ontario Stocking Standards for Timber Production F.C. Robinson—July 1977

I. Description of Terms

Stocking:

The measure of the distribution of trees expressed as a percent of quadrats stocked. Quadrat size is five square metres (approximately 1/800 acre).

Good Stocking:

This is the minimum stocking required, at the end of the regeneration period, for good forest management. It is expected to produce a stand at maturity with a factor of at least 0.8 of normal stocking, according to the Normal Yield Tables for Ontario.

Failure:

Regeneration assessed as failure cannot be considered to be capable of producing a merchantable crop. Further treatment, or further time, may permit reassessment.

Fair Stocking:

This is regeneration assessed between good stocking and failure. It can be expected to produce a merchantable crop, but much less than its potential, or with a longer rotation.

Primary Species:

This corresponds with the working group species. They must be suitable to the site.

Secondary Species:

Species, other than the primary species, suitable to the site and will contribute to the harvest.

Regeneration Period:

The number of years required for regeneration to become established. A stocking assessment should be made at the end of the regeneration period. This is set at five years. It may be advanced to three years for aspen sucker stands or delayed to seven years for natural regeneration systems.

II. Explanatory Notes

Quadrat Size:

This has been increased to 5 m^2 (1/800 ac.) from 4 m^2 (1/1000 ac.). This change assumes a desirable spacing of 2.25 m (7.4 ft.) instead of 2 m (6.6 ft.).

Good Stocking:

This should be our aim in all sites, and must be achieved where planting or intensive management is needed to meet targets.

Fair Stocking:

This is acceptable where extensive management is intended or where natural regeneration systems are in use. Yields can be expected to be lower or of less desirable species. This must be considered when determining regeneration targets to reach volume output targets.

Density:

References to density (number of trees per unit area) have been omitted. At the present time, it is considered too expensive to measure numbers of trees in a statistically sound manner. Competition problems must be considered in relation to tending rather than in relation to stocking.

Table C1. Province of Ontario Stocking Standards for Timber Production (1977).

Working Group	Primary Conifer	Primary Hardwoods	Secondary Conifer	Secondary Hardwoods	Primary & Secondary Conifer	Primary & Secondary Hardwoods	Total Primary & Secondary
Black Spruce	Sb		Sw, Pj, B, L, Ce	Po			
Good	≥ 60%						≥ 70%
Failure	< 40%				< 50%		< 50%
White Spruce	Sw		Sb, Sr, Pr, Pw, Pj, B, He	Po, Bw tolerant hardwoods			
Good	≥ 50%						≥ 70%
Failure	< 40%						< 50%
Jack Pine	Pj		Sb	Po			
Good	≥ 60%						≥ 70%
Failure	< 40%						< 50%
Balsam Fir	B		Sw, Sb, Pj	Po			
Good	≥ 40%				≥ 50%		≥ 70%
Failure	< 30%				< 40%		< 50%
White Pine	Pw		Pr, Pj, B, spruce, He	Po tolerant hardwood			
Good	≥ 50%						≥ 70%
Failure	< 30%				< 40%		< 50%
Red Pine	Pr		Pr, Pj, Sw, Sr				
Good	≥ 50%				≥ 70%		≥ 70%
Failure	> 40%				< 50%		< 50%
White Spruce Mixedwood	Sw		Sb, Sr, Pj, Pr, Pw, B, He	Bw, Po tolerant hardwoods			
Good	≥ 30%			≥ 20%	≥ 40%	≥ 20%	≥ 70%
Failure	< 30%			< 10%			< 50%
Other Conifer	Ce, L		Sb, B, Sw, Pw				
Good	≥ 50%				≥ 70%		≥ 70%
Failure	< 30%				< 50%		< 50%
Poplar		Po	Sw, Sb, Pj, Pw, B	Bw			
Good		≥ 70%					≥ 80%
Failure		< 40%					< 50%
White Birch		Bw	Sw, Sb, Pj, Pw, B	Po			
Good		≥ 60%					≥ 70%
Failure		< 40%					< 50%
Tolerant Hardwood & Hemlock		All commercial hardwoods suitable to site	He, Pw, Sw, Sr				
Good		≥ 70%					≥ 80%
Failure		< 50%					< 50%

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